frontiers in Marine Science

ORIGINAL RESEARCH
published: 14 January 2020
doi: 10.3389/fmars.2019.00795

Stakeholder Perspectives on Opportunities and Challenges in Achieving Sustainable Growth of the Blue Economy in a Changing Climate

Christina Hoerterer[1], Maximilian F. Schupp[1,2], Andreas Benkens[1], Dustin Nickiewicz[1], Gesche Krause[1] and Bela H. Buck[1,3]*

[1] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany, [2] School of Social Sciences, University of Dundee, Dundee, United Kingdom, [3] Faculty 1, Applied Marine Biology and Aquaculture, University of Applied Sciences Bremerhaven, Bremerhaven, Germany

OPEN ACCESS

Edited by:
Francisco Leitão, University of Algarve, Portugal

Reviewed by:
Michael J. Harte, Oregon State University, United States
Maria Hadjimichael, University of Cyprus, Cyprus

***Correspondence:**
Christina Hoerterer
Christina.Hoerterer@awi.de;
christina-hoerterer@hotmail.de

Specialty section:
This article was submitted to Marine Fisheries, Aquaculture and Living Resources, a section of the journal Frontiers in Marine Science

Received: *31 July 2019*
Accepted: *10 December 2019*
Published: *14 January 2020*

Citation:
Hoerterer C, Schupp MF, Benkens A, Nickiewicz D, Krause G and Buck BH (2020) Stakeholder Perspectives on Opportunities and Challenges in Achieving Sustainable Growth of the Blue Economy in a Changing Climate. Front. Mar. Sci. 6:795. doi: 10.3389/fmars.2019.00795

Coastal marine environments provide livelihoods as billions of people around the world depend greatly on sustainability efforts in the Blue Economy. In this study, we investigated how stakeholders from important Blue Economy sectors along the German North Sea coast perceive the impacts of climate change on their daily work life and the growth of the Blue Economy. In a two-stage approach we first conducted two stakeholder workshops with representatives from the regional sea food sector, science, NGOs and local authorities, in order to identify important issues linked to climate change affecting environment, society, economy and policy. In the second stage, we conducted semi-structured interviews with key knowledge holders from the Blue Economy, to evaluate and validate the most important issues identified during the first stage, and the impacts on the respective sectors. The workshop participants identified perceptible effects of climate change on their marine environment. Early career scientists showed that they possess a clear focus on measures for climate change adaptation, transdisciplinary approaches and knowledge transfer. The interviews revealed that the climate change effects could be perceived as both negative and positive, depending on the sector. Other issues, especially political decisions and developments are perceived to have a greater immediate impact on the Blue Economy than the slow progress of climate change effects. Additionally, increased human activities, in the form of new or intensified uses like marine renewable energy generation, have a greater influence and lead to conflicts between the Blue Economy sectors. Our study showed that economic and societal stakeholders in Germanys North Sea region are aware of climate change and already perceive its effects on their businesses. Synergies and conflicts between the sectors and political decisions might influence sustainable growth of the Blue Economy in highly contested regions, such as the North Sea basin, much stronger than the effects of climate change. This calls for a more flexible and adaptive approach to policymaking, taking into account the changing environmental, social and economic realities.

Keywords: adaptation, fisheries, tourism, North Sea, aquaculture, blue growth, seafood

INTRODUCTION

With 40% of human population living within 100 kilometers of the coast (UN, 2017), coastal marine ecosystems are among the most ecological and socio-economic valuable in the world. Livelihoods of people around the world are part of coastal socio-ecological systems (SES) and depend on the ecosystem goods and services that healthy coastal and marine systems provide (Seitz et al., 2013). However, there is a scientific consensus that coastal marine ecosystems and their goods and services are increasingly threatened by anthropogenic activities and pressures, such as marine resource use, building measures, and global climate change (IPCC, 2018). Shifts in water temperatures, ocean acidification, rising sea level, changes of ocean circulation patterns and increasing nutrient input are affecting physical, chemical and biological processes (Doney et al., 2012) that lead to changes in primary and secondary production, shifts in the distribution of species, changes in the biodiversity and population dynamics (Harley et al., 2006).

Understanding the Concepts of Blue Economy and Blue Growth

The above-described trajectories of change pose future opportunities and challenges for coastal communities, including people working in maritime economy sectors, such as fishery, aquaculture, and tourism. Endorsing the three pillars of sustainability, societal, ecological and economic aspects (Allison et al., 2009) need to be addressed in order to ensure sustainable development. There are different terms, concepts and strategies related to fostering and managing sustainable development of the oceans. Blue Economy emerged in the early 2010s from a need to incorporate sustainability and conservation into the management and development of the ocean economy in order to reduce environmental risks, e.g., lower greenhouse gas emissions, less pollution while fostering resource efficiency (UN, 2014). Along with Blue Economy, the concept of Blue Growth is used for a holistic management of marine SESs focusing especially on sectors with a high potential for sustainable growth. The European Union launched its Blue Growth strategy to stimulate the economic growth of five areas in European seas: aquaculture, coastal tourism, marine biotechnology, ocean energy and sea bed mining, whereas other Blue Economy sectors like transportation, fisheries, shipbuilding and offshore oil and gas are already well established in terms of value and jobs (EC, 2017). In previous years, the concepts of Blue Economy and of Blue Growth has received criticism from different sides, since the goals are not clearly defined and stakeholders thus interpret Blue Economy and Blue Growth in different ways (Voyer and van Leeuwen, 2019).

Silver et al. (2015) and Voyer et al. (2018) identified four lenses of how Blue Economy can be seen by the actors. These views can be synthesized representing two distinct contrasting perspectives: (1) ecosystem goods and services based: ocean as natural capital (lens 1) and livelihood for coastal communities (lens 2) such as small-scale fisheries and Small Island Developing States and (2) solely ocean economy based: oceans as good businesses (lens 3) and drivers of innovation (lens 4).

Many authors see the danger of the privatization of common property ocean spaces through blue economy (Voyer et al., 2018) and this leading to "ocean grabbing" neglecting the needs of and rights of smaller sectors in favor for private-profit interests (Barbesgaard, 2018). Furthermore, the question arises whether Blue Growth is achieved by "maximizing economic growth derived from marine and aquatic resources" or "by maximizing inclusive economic growth derived from marine and aquatic resources and at the same time preventing degradation of blue natural capital" (Eikeset et al., 2018). In this study, we investigated, how the local actors in the Blue Growth and Blue Economy sectors perceive sustainable development and if they try to achieve sustainable growth attaining economic, societal and environmental sustainability at the same time.

In the German North Sea region, the Blue Economy sectors with the most future potential are offshore wind energy, coastal tourism, shipping, cruise tourism, shipbuilding and ship repair and marine aquatic products (fisheries, aquaculture and fish processing) (EU, 2016). In this study, we investigated, how the local actors in the Blue Growth and Blue Economy sectors perceive sustainable development and their issues related to achieve sustainable growth to attaining economic, societal and environmental sustainability at the same time.

Climate Change Impacts of the Blue Growth and Blue Economy in the North Sea Region

The North Sea and especially its southern coastline are a focal point for the effects of global climate change and this is exacerbated by the intense anthropogenic use of the marine environment (Emeis et al., 2015). It is precisely here that the effects of climate change described above can be clearly seen as well as the resulting effects on the ocean economy (see **Table 1**). The main issue is the increase in sea surface temperature, which has, in combination with other climate change related factors, the biggest influence on the marine environment. Correlated to increasing sea surface temperatures is the increase in biomass production as it is observed and predicted for the North Atlantic and North Sea in phytoplankton and higher trophic levels (Brander, 2010). This increased biomass of lower trophic levels has a bottom up effect leading to an increased fish biomass, but also to blooms of harmful microalgae, macroalgae and jellyfish affecting the fisheries, aquaculture and tourism sectors (Peperzak, 2003; Attrill et al., 2007; Callaway et al., 2012). Furthermore, valuable fish and mussel stocks show geographic shifts northwards (Perry et al., 2005; Rijnsdorp et al., 2009; Jones et al., 2010) or into deeper waters (Dulvy et al., 2008) affecting seafood production and tourism. The rising sea surface temperature in the North Sea also leads to changes in the North Sea food web, resulting in a mismatch between trophic levels (Edwards and Richardson, 2004) and in changes of the community composition (Franke and Gutow, 2004; Wiltshire et al., 2009), which is mainly affecting the seafood and tourism sector. Climate change can facilitate the spread and settlement

TABLE 1 | Overview of climate change effects and impacts on Blue Economy sectors in the German North Sea region; sectors with * are considered as Blue Growth sectors (Schuchardt and Wittig, 2012).

Effects	Impacts	Fisheries	Aquaculture*	Fish processing	Transportation	Coastal tourism*	Wind energy*	Biotechnology*
Increase in sea surface temperature	Increase in biomass production	x	x				x	x
	Toxic algal blooms	x	x		x	x		x
	Geographic shifts of fish stocks	x				x		
	Migration of neobiota	x	x		x			x
	Change in food webs		x					
	New culture species		x					
Extreme weather events	Intensification of wind and sea conditions	x	x		x	x	x	x
	Flooding of coastal infrastructure			x			x	x
	Damage of production infrastructure		x		x	x	x	x
	Increased risk of diseases		x			x		
	Coastal erosion				x	x		
Ocean acidification							x	x
	Decrease in fish and mussel stocks	x	x					
Change in circular patterns		x			x	x	x	
	Variations in salinity	x				x	x	x
Increased air temperatures	Increased cooling requirement for equipment	x		x			x	
	Unsteady supply of feeds		x					
Sea level rise					x	x		x
Increased precipitation	Pollution (effluents, nutrients, and chemicals)	x	x		x	x		x

of new species introduced through human activities, such as shipping (trade and leisure) and aquaculture (Hellmann et al., 2008) posing challenges and opportunities for the Blue Economy sectors. This development can be positive, when new species are valuable for human consumption and other purposes can form a new income for fisheries (Cheung et al., 2012; Heath et al., 2012) and aquaculture. Challenges as the spread of potentially invasive species, pathogens and disease vectors, can be an opportunity for growth in the blue biotechnology (Burge et al., 2014). Due to changes in atmospheric and ocean circulation patterns it is predicted that extreme weather events will occur more frequently and wind and sea conditions will intensify leading to stronger storms, storm floods and harsh sea conditions affecting the fishing sector as well as coastal and offshore infrastructures (Westlund et al., 2007). For instance, high waves and strong winds may reduce sea time and destroy infrastructures for mussel culture at sea (Westerbom et al., 2019). Ocean acidification has the potential to threaten especially mussel farmers, by reducing mussel stock in vulnerable stages (Callaway et al., 2012). Increased precipitation combined with anthropogenic activities, such as agriculture, may lead to an increased riverine runoff loaded with harmful substances, ranging from toxins, heavy metals to high nutrient concentrations (Lowe et al., 2009). These pollutants can contaminate wild and cultured fish and shellfish stock, making them unsuitable for human consumption, leading to economic loss for fishermen and aquaculture producers (Callaway et al., 2012).

Point of Departure

Metcalf et al. (2015) showed how the knowledge of representatives from communities could help in identifying components of adaptive capacity and vulnerability as well as act as potential enablers and barriers to the implementation of adaptations. The point of departure of this article is rooted in the assumption that climate change may already limit coastal communities in their ability and capacity to move into more transformative pathways toward a sustainable Blue Economy and Blue Growth state. In order to unlock the transformative potential, we investigated how stakeholders from important Blue Economy and Blue Growth sectors perceive the impacts of climate change on their daily work life and how they judge the prospects of future sustainable growth of the Blue Economy. Toward this end, we employed a case study approach focusing on stakeholders along Germany's North Sea coast. Coastal inhabitants, who directly interact with the marine environment, are often acutely aware of the changes happening in their surroundings (Döring and Ratter, 2017). The results within this study stem from two consecutive projects, which focused on the impacts of climate change on the local seafood sector and other Blue Economy sectors in the German North Sea region around

the city of Bremerhaven. The goal of the projects was not only to collect data regarding the perceived effects of climate change (Hörterer et al., 2017) but also to foster bi-directional knowledge transfer between all involved actors (Hörterer et al., 2018) in order to increase their collective transformative capacity. The study, the workshops and interviews presented in this paper built on preceding extensive stakeholder mapping to identify key actors and knowledge holders in the regions and relevant sectors.

METHODOLOGY

As part of a two-stage approach, we first conducted two stakeholder workshops in order to capture the perceptions and knowledge of climate change and its impacts on the region and its population. The second stage consisted of a number of personal semi-structured interviews with representatives of Blue Economy sectors located in the region.

Workshops With Key Knowledge Holders From Science, Fisheries, Fish Processing, Authorities and NGOs to Exchange Knowledge on the Most Important Effects of Climate Change on the Environment, Society, Economy and Politics in the Region

For the first stage, we chose a workshop setting to facilitate a dialogue between all participants on an even level. The first workshop (WS1), was hosted at the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven in June 2016 as part of the "European Maritime Day 2016" activities and was directed toward a selected audience of 13 key local knowledge holders from fisheries (n = 1), aquaculture (n = 1) and fish processing industry (n = 1), science (n = 7), NGOs (n = 1) and local authorities (n = 2). The key knowledge holders were identified and selected through their position within a company or organization. We contacted 43 persons via telephone or email of which 70% (n = 31) responded and 42% (n = 13) participated in the workshop. The second workshop (WS2), hosted as a part of the "YouMaRes 7" conference in Hamburg in September 2016, focused on early career scientists (n = 23; 2 Bachelor students, 7 Master students, 8 Ph.D. students, 3 students undefined, 2 scientists (MSc degree), and 1 first year PostDoc) from different research fields (biology, ecology, chemistry, and social sciences) in order to get an unbiased view on environmental topics and research issues without the influence of more experienced scientists. Furthermore, the prospective scientists from tomorrow show a greater interest in climate change, sustainability and transdisciplinary dialogue and should be listened to and be given a voice. This two-pronged approach emulates a longitudinal study using two focus groups from different age brackets and career stages in order to achieve a cohesive overview of knowledge and perceptions about climate change impacts. Both workshops used the World Café methodology to support knowledge exchange and formation of opinions (Brown and Isaacs, 2007). In WS1, the participants were seated in mixed groups, while these groups were arranged in order to facilitate discussion and communication within their group but also with all participants in the room. In WS2, the participants were seated in a loose circle facing the front, facilitation communication with the moderation and with each other. Short impulse talks by experts from science introduced the participants into specific topics on the effects of climate change on the environment to help participants reach a common baseline of knowledge. After each impulse talk, an open discussion round with all participants showed the perceptions toward the presented topics. During all talks and sets of discussions, the participants were asked to note issues of climate change that they perceived as important on file cards. In the final discussion and synthesis round the participants rated the issues by their personal perceived importance with points. Each participant was able to give a maximum of five points in total – giving either one point to five different issues or five points for one issue or anything in between. In the final step, the most important issues with three or more points were discussed jointly in the audience and related to field clusters they may affect. Those fields were (1) environment, (2) economy, (3) policy, and (4) society. The aim of WS1 was to gather the knowledge from a broad audience, thereby getting multiple perceptions from different viewpoints. By identifying and discussing possible effects of climate change, stakeholders were able to identify risks as well as opportunities, which may arise from climate change. The aim of WS2 was similar to WS1, identifying and discussing impacts of climate change, risks and opportunities. On this basis, strategies for environmental education and future research strategies were discussed. Additional data were collected by qualitative transcription of the discussions throughout both workshops and analyzed as part of this study.

Semi-Structured Interviews

In the second stage of this study, we conducted 25 face-to-face semi-structured qualitative interviews from September to October 2018 with actors from various Blue Economy sectors situated in the region of three coastal states of North–West Germany bordering the German bight (North Sea): Bremerhaven/Bremen, Lower Saxony and Schleswig-Holstein. We conducted a stakeholder mapping of companies associated with Blue Economy sectors located and acting in the study area. In order to get an equal representation of the perceptions and views within the companies and the sectors, we targeted interview participants that we could expect to have high level of knowledge about the company's efforts and a good overview over the sector's challenges and opportunities. We selected the participants due to their position within the company, being executive directors, company communications manager, and head of department. The distribution of the participants reflects the number of Blue Economy sectors in the study area. In total, we contacted 46 companies of which 67% (n = 31) responded and of which 80% (n = 25) participated in the interviews. All companies from aquaculture (n = 2), fish processing (n = 5), and consulting (n = 1) contacted, also responded and participated in the interview. The wind energy sector had the second highest response rate 73% (8 respondents out of 11 contacted), and four of the respondents

participated in the interviews. In the fisheries sector three out of five responded and two participated. In both, the transport and biotechnology sectors, seven companies were contacted and four responded respectively, all respondents of the transport sector participated, whereas in biotechnology three participated. In the tourism sector four out of eight responded and all respondents were interviewed.

The semi-structured interviews were divided into three parts, with the aim of affirming and validating the topical findings of both workshops. Central herein was the focus on the perceived causes and impacts of climate change on the local social communities and the environment. Furthermore, we asked how climate change affects the Blue Economy sectors they are a part of, drivers and pressures enabling or restricting the growth of the Blue Economy. The second part addressed the issue of sustainable development of the Blue Economy in the face of climate change, climate change mitigation and globalization. Under this umbrella, we asked specifically for constraints and opportunities for sustainable growth on local, regional, national and international levels.

The most important outcomes from both workshops were summarized and presented to the stakeholders of the different Blue Economy sectors in individual interviews. From a selection of 14 environmental changes identified by stakeholder groups (see **Table 2**), they were asked to name those which they already experienced in their daily business and classify whether that change has a positive, negative, or neutral effect on their business. Effects were rated with no relevance (0%), low level of relevance (1–35%), moderate level of relevance (36–70%), and high level of relevance (71–100%). Effects, which have been evaluated by the majority of the respective group (always $\geq$ 50%) positively, have been marked green. Yellow field marks suggest that the majority of the group consider the respective outcomes as neutral. Red field marks implied that the majority have valued the respective ramification negatively.

Conceptual Model

In both stages of the study, we encountered a large and narrative rich knowledge base about climate change and its effects on the environment. We adopted the conceptual model approach from Tiller et al. (2016), in order to display the coherences of the effects of environmental change as well as political and social influences mentioned by the participants. We created the conceptual model using the Vensim (2015) software, displaying the coherences graphically by placing the topics in circles, and their respective size equals the perceived importance to the stakeholders. Topics perceived as more important are represented by larger circles. Causal conjunctions between different topics as experienced and perceived by stakeholders are displayed with arrows between topics.

RESULTS AND DISCUSSION

In the following, we present and discuss the effects of climate change on the environment, economy and socio-economy, and the political, societal and cultural issues mentioned and perceived by participants of the two workshops. We then present and discuss the effects of climate change on the Blue Economy, the perceived limitations and opportunities, which derive from climate change and within the Blue Economy enabling sustainable growth for the region. As the seafood sector, combining fisheries, aquaculture and fish processing industry, is of great importance for the region, we discuss in detail the

TABLE 2 | Climate change related environmental changes ranked by stakeholders from different sectors of Blue Economy in single interviews (n = 25).

Effects	Impacts	Seafood	Transportation	Coastal tourism*	Wind energy*	Biotechnology*	Total
Increase in sea surface temperature		Low	Low	High	Low	Low	Low
	Increase in biomass production	High	Low	High	Low	Low	Medium
	Toxic algal blooms	High	Low	High	No	No	Medium
	Geographic shifts of fish stocks	High	Low	High	No	No	Medium
	Migration of neobiota	High	Medium	High	Low	Medium	Medium
	Change in food webs	High	Low	Medium	No	Low	Medium
Extreme weather events		Low	No	High	High	No	Low
	Intensification of wind and sea conditions	High	High	High	High	No	High
	Flooding of coastal infrastructure	Medium	High	High	Low	No	Medium
	Coastal erosion	Medium	Low	High	No	No	Medium
Ocean acidification		Low	Low	Medium	No	Low	Low
	Decrease in fish and mussels stocks	Medium	Medium	High	No	No	Medium
Increased air temperatures		Low	No	High	No	Medium	Low
	Increased cooling requirement for equipment	High	Low	High	No	Low	Medium

*The level of relevance for the respective sectors are given as no (0%), low (1–35%), medium (36–70%), and high (71–100%). The perception of the environmental changes are marked green for positively, red as negatively results and yellow as not clearly neutral. Sectors with * are considered as Blue Growth sectors.*

implication for the seafood sector as well as for the other regional Blue Economy sectors.

Overall, in the study, all involved stakeholders are aware of climate change and perceive the impacts in their daily life, private or work related. The conceptual model (see **Figure 1**) visualizes the coherences between the issues perceived as important by the stakeholders involved in this study.

Effects of Climate Change on the German North Sea Identified in the Workshops

In the workshops, the participants mentioned in total 50 issues, which they felt related to climate change: 21 of them where mentioned by the senior practitioners (WS1) and 29 by the early career scientists (WS2), respectively. The allocation of these issues into the fields (1) environment, (2) economy, (3) policy, and (4) society showed some differences between the two workshops. Environmental issues were in WS1 as well as WS2 the most mentioned topic, with 62% (13) in WS1 and 55% (16) in WS2. Only the participants from WS1 mentioned economic issues with 10% (2) allocations. Policy issues were the second most important issue in WS1 with 19% (4) allocations and 10% (3) for WS2. Societal issues were of great importance for WS2 with 28% (8) allocations and with lesser importance for WS1 5% (1). In both workshops, 6% (3) of the mentioned issues were related to scientific practice.

Environmental Impacts

The major issue often raised by various stakeholder groups in both workshops pertained to the impacts of climate change on the biological, chemical and physical components of the marine

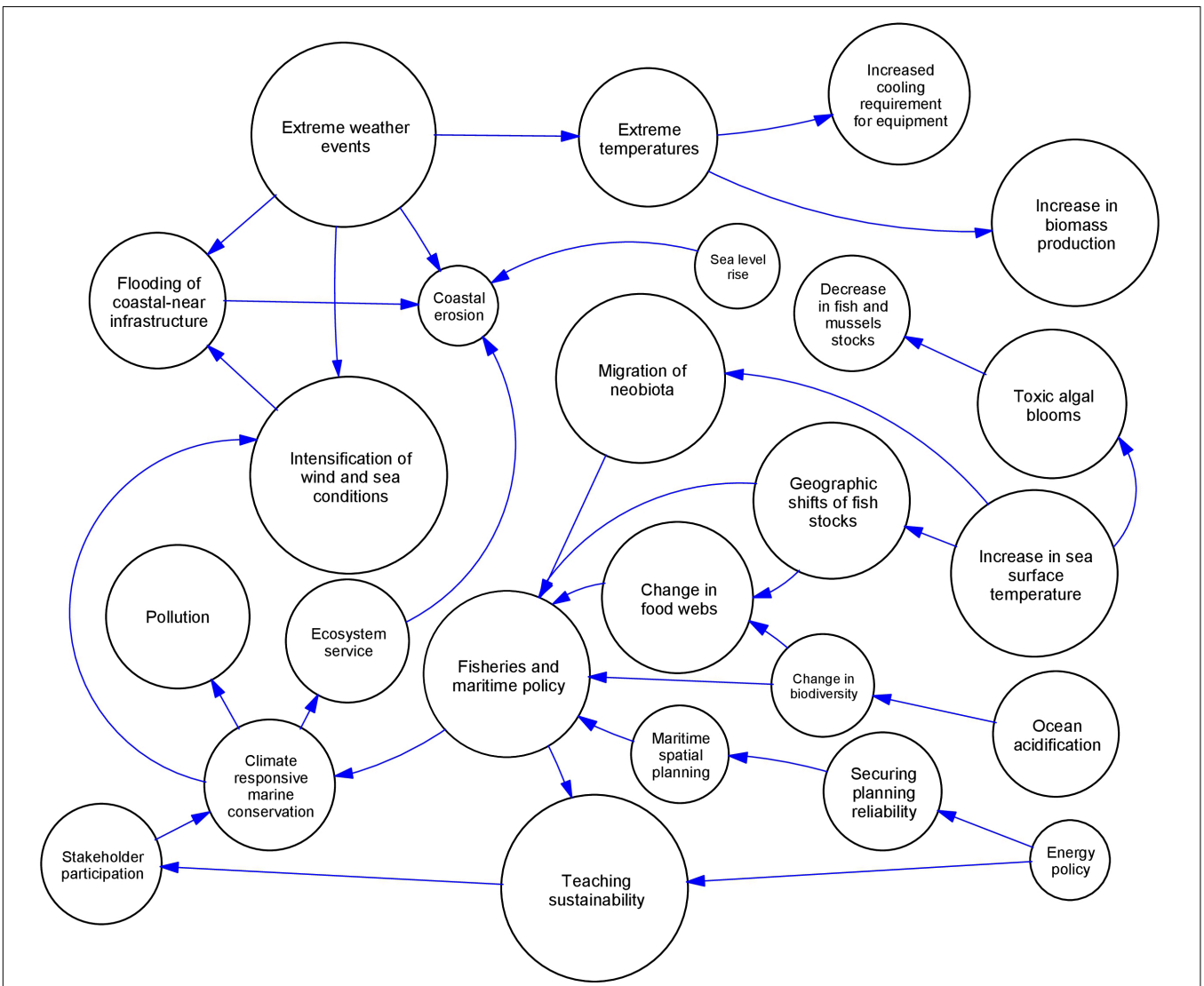

FIGURE 1 | Conceptual model of climate change induced environmental changes and socio-economic drivers as perceived by stakeholders of the Blue Growth realm transcribed from the workshops and interviews. Bubble size reflects importance. Created using Vensim.

environment. The participants identified the presently more frequent and more intense occurring extreme weather events as the most important issue affecting the natural environment and thus their work life. Scientists and practitioners were concerned that onshore, intertidal and subtidal habitats are being lost or degraded through a combination of climate change impacts and anthropogenic activities. Building measures such as dikes and other coastal protection to safeguard coastal populations from storm surges and increased wave heights may lead to a destruction of coastal habitats (on shore and intertidal). These coastal infrastructures may directly or indirectly restrict the natural movement of the habitats as response to rising sea level inland (Reise, 2005). For the aquaculture sector, in the German North Sea predominantly shellfish (blue mussel and pacific oyster), the participants voiced concern that these species will be affected by extreme warm water temperatures in summer and extreme cold water temperatures in winter, thus potentially limiting aquaculture production of these contemporary species as alternative future income option (Hawkins et al., 2013). Marine finfish aquaculture would be affected too (Callaway et al., 2012); however, to date finfish aquaculture is limited to the German Baltic Sea region. The main concern scientists have is that climate change is affecting the functional diversity of ecosystems. There are two scenarios; (1) that native species are declining in abundance or getting lost, so the functional diversity of the ecosystem is threatened; (2) the declining native species are replaced by new species either introduced by human activity vectors or migrated from the South to the North (Sorte et al., 2010). Representatives from science were also concerned about algal blooms caused by a combination of warmer water temperatures, eutrophication and new species with a great potential for forming blooms. The effect of algal blooms on the fisheries and aquaculture sector can be both, positive and negative. Greater availability of food in the ecosystem can increase the productivity of the system positively affecting fisheries and shellfish aquaculture production volume. On the other hand, harmful algal blooms can either reduce the productivity of fish stock and shellfish by toxins, or reduce the quality of shellfish, or the shellfish producers are not able to sell their products in certain months when toxic algal blooms may occur.

Early career scientists participating within the WS2 showed a different approach to the topic than the stakeholders of WS1 did. They perceive pollution with harmful substances (toxins, heavy metals and nutrients) of marine waters because of increased precipitation as an important issue. For early career scientists invasive species are seen as an important issue as climate change can facilitate the spread and settlement of new species. The representatives from seafood production and processing perceive the migration of southern warm adapted species to warming northern sea basin as both, positive and negative.

Economic and Socio-Economic Effects

Fishermen and representatives from the fish processing industry voiced concern about the price for raw fish, which is likely to increase in future due to the effects of a changing environment besides other factors. The participants from both workshops saw the livelihoods of local fishermen as well as of the coastal population employed in fish processing and tourism being critically threatened by environmental changes, as well as societal and political issues and framing. Additionally, the impacts on ecosystem goods and services providing value for the fish producing and processing sector as well as for tourism by a good environmental status were perceived as an issue on the economy and socio-economy along the North Sea coastline. More specifically, representatives from the fishing sector raised concern that the increasing frequency and strength of storms will affect the time on sea and therefore indirectly their income by more limited numbers of available fishing days. Furthermore, they raised the need to reconsider the contemporary design of fishing vessels, in order to adapt the design of ships to increasing strength and severity of storms and wave heights while providing work safety also under extreme conditions.

Policy Issues

Representatives from science and the fisheries sector concurred that fisheries policy and management has to adapt to climate change related shifts in the range of relevant species, both native and new species migrating north. Practitioners and scientists mentioned more flexible and faster adapting fisheries policy and management is needed to address the year-to-year changing distributions and abundances of commercially valuable fish stocks (Cheung et al., 2017). The participants argued that catch quota need to include new species to avoid a reducing effect on the total catch by "choke-species" such as cod and hake (Baudron and Fernandes, 2015; Mortensen et al., 2018) and to include new valuable species such as Sea bass and Red mullet (Brander et al., 2003). All participants from WS1 perceived a great need for marine spatial planning (MSP), taking the recent and future changes in the environment and ecosystem caused by a changing climate more strongly into account to avoid future conflicts between stakeholders and users. In the case of the German North Sea the needs of all actors, which use mobile resources (especially for fishermen), the range and abundance of target species and nature conservation interests need to be considered in future planning. Scientists and representatives from nature conservation agree on the implementation of marine protected areas (MPAs) as refuge for native species threatened by climate change. As aforementioned, all future planning for the use of marine areas, predicted changes in the abundances and species range under climate change need to be considered when new MPAs are planned or existing are going to be extended.

Societal and Culture Issues

Participants from both workshops agreed that society with all facets of employees, tourists, etc., need to adapt to the changing climate. Climate adaptation strategies for the sectors affected by a changing climate need to be developed. In the study area, climate adaptation strategies are developed and proposed for the state of Bremen (Koch et al., 2015) and for the metropole region Bremen–Oldenburg (nordwest2050, 2014). The participants from both workshops agreed that the efforts for knowledge transfer and education need to be intensified in all parts of society from early

school onto third education schemes (i.e., into the curriculum of various science fields).

The early career scientists' group mentioned that local fishing communities have besides their economic value, also a cultural value from which especially the tourism sector is profiting. In northern Germany local communities developed 'integrated development strategies' for fisheries in 'Fisheries local action groups (FLAGs)' (AFW and COFAD, 2007; RegionNord, 2015; FBG and COFAD, 2016), targeting the integration of tourism, fisheries and climate change effects.

Climate Change Effects on Blue Economy: Limitations and Opportunities

In the interviews, 88% of the respondents (22 persons) stated that the major cause for climate change is attributed to anthropogenic activities. Furthermore, 76% (19 persons) defined specifically the emission of carbon dioxide as a driver for climate change. A correlation with natural climate change is mentioned by 36% of the respondents (9 persons). Intensive livestock farming and deforestation of rainforest are seen by 20% (5 persons) as a cause for climate change, respectively. Presenting the findings from the two workshops to actors from the Blue Economy in single interviews, they mostly agree and confirm the insights elaborated. The ranking of different environmental changes perceived by the different stakeholders in their realm are shown in **Table 2**.

Practitioners from sectors operating at sea, such as the wind energy, transport and seafood sector, are affected by increasing sea surface temperatures negatively, but the relevance of the impact is low. The tourisms sector will strongly benefit from warmer coastal seawater in summer attracting more tourists at the German beaches as an alternative to southern European destinations. The increase in biomass production and the subsequently increased fish biomass are of high relevance for the seafood and tourism sector, whereas the impact differs, not clearly negative or positive for seafood. Blooms of harmful microalgae, macroalgae and jellyfish have negative impacts for tourism fearing that the blooms deter tourists, when occurring close to the beaches. These blooms also have a high relevance for seafood, with mainly negative impacts, damaging fish and mussel stocks as well as decreasing the value of shellfish and other seafood products for human consumption. The geographic shift of fish and mussel stocks are of high relevance for the seafood and tourism sector, but the impacts are not clearly positive or negative. Representatives from the seafood and tourism sector perceive the changes in the North Sea food web as mainly negative because they fear that valuable native species disappear. The migration of neobiota and potential invasive species pose challenges and opportunities for the Blue Economy sectors. The maritime transport industry must focus on ballast water management, so non-native organisms are not transported as "stowaways" in the ballast water on ships worldwide and potentially become invasive species (Occhipinti-Ambrogi, 2007). Neobiota are of high relevance with negative impacts for seafood, if the new fish species have no or only small catch quota, or if low-value fish species replace high-value species. For the blue biotechnology industry neobiota pose the potential to develop new products in diagnostics for the detection of potentially invasive species, pathogens and disease vectors and thus to generate new revenues.

The respondents agreed with the findings from the first workshop that the increase in frequency and intensity of extreme weather events affects their sector, whereas the impact varied between the sectors. Respondents from the seafood and wind energy sector are mostly affected from intensification of wind- and sea conditions, affecting their activities on sea. As already mentioned by the participants in WS1, the representative from fisheries and aquaculture mentioned that high waves and strong winds may reduce sea time and destroy infrastructures for mussel culture at sea. The tourisms sector will not be affected strongly since cold temperatures and strong winds and storm mainly occur in the off-season, in winter. Ocean acidification threatens especially mussel farmers, by reducing mussel stock in vulnerable stages. This is also negatively affecting the tourism sector since locally sourced and produced seafood are attractive for tourists as they shape their perception of a viable waterfront at the coast.

Limitations for Sustainable Growth Within the Economic, Political and Societal Frameworks

Asking stakeholders from different Blue Economy sectors, which dimensions of sustainability (economy, society, and environment) are the limiting part in the sustainable growth of the company and the sector in general, 76% of the respondents named economical obstacles to be the greatest hurdle for sustainable growth. Societal and environmental obstacles play a similar role for 56 and 52% of the respondents, respectively. Sixteen percent of respondents saw no obstacles for sustainable growth of their company.

The representatives from fisheries and wind energy mentioned the spatial use conflict between the sectors as the main reason for limiting for sustainable growth. With the growing offshore wind energy industry available space for fishing becomes limited, since more space for offshore wind farms in the German EEZ is planned, where no others uses are allowed (BMVBS, 2009). Nature conservation interests add more pressure to the spatial use conflict between all actors. These conflicts are imminent for the German North Sea region, because the UNESCO world heritage site and national park Wadden Sea ranges along the entire North Sea coast from the Netherlands in the west, along the entire German North Sea coast to Denmark in the North. Protected areas, which are traditionally fished and used by the local fishing communities, may be closed for commercial and recreational fisheries (Carstensen et al., 2014). Most traditional fishing communities target coastal species such as flatfish, brown shrimp and mussels and are therefore most affected by restrictions in coastal waters. Additionally, respondents from the seafood sector hold a bad representation by nature conservationists in media. Another possible friction seen is the combination of tourism and transport sector. Cruise tourism is an increasing industry but the respondents are worried about the additional pollution coming from these vessels (Klein, 2011) adjoining

to the pollution of cargo vessels in the harbors. Respondents from the single interviews emphasized the need of political and regulatory adaptations. Small and medium enterprises (SMEs) dread to promote for funding programs because of the administrative process, which is perceived as to complicated, obscure and too long.

Opportunities Between the Sectors to Enable Sustainable Growth

The respondents from the seafood and wind energy sector expressed that they themselves have a solution to spatial use conflicts and are asking for MSP, a tool to reduce use conflicts arising from the expansion of offshore wind energy, fisheries and other Blue Economy sectors (Douvere and Ehler, 2009). As mentioned by representatives of both sectors, multi-use of the space within the safety zones of wind farms for aquaculture of mussels and macro algae as well as for passive fisheries on brown crab might be an opportunity for enabling sustainable growth through spatial efficiency (Schupp et al., 2019). Interacting with the tourism sector in the region is perceived as an opportunity for these sectors as well. The traditional coastal fisheries and harbors are iconic for maritime environment and therefore important for the tourism sector. Locally produced and processed seafood is both beneficial for fishermen (Stoll et al., 2015) and tourism operators as it was shown for rural tourism (Sims, 2009). Likewise, the respondents from wind energy see the opportunity to present offshore wind farms as a tourist attraction and familiarize people with the technology and benefits of renewable energy. Respondents from the fisheries sector also see synergies with nature conservation, because the traditional coastal fisheries are also interested in the conservation of a functional environment, providing them with sustaining ecosystem goods.

Implications for Fostering Sustainable Growth in the Blue Economy

All addressed stakeholders were aware that political processes to change regulations and implement adaptation strategies take up to 10 years or longer. This makes short-term adaptations and measures difficult to implement, and long-time investments risky to plan. Additionally, short-term changes in societal and political trends on international, national, and regional levels within the slow moving political processes may interfere with sustainable growth and climate adaptation strategies on local levels.

For the practitioners in the Blue Economy sector climate change is a fact and they are willing to take measures for adaptation, transformation and mitigation. In order to achieve sustainable growth, all enterprises and especially SMEs are asking for reliable political framework conditions and low administrative obstacles to initiate new developments, also in cooperation with science, under the umbrella of sustainable development and innovation. Interestingly, senior scientist and experienced practitioners raised tangible physical, biological and economic issues and challenges as ways to adapt to climate change. Contrastingly, early career scientists mentioned mainly societal factors, asking for measures to stop climate change and to implement more sustainability in the Blue Economy and society. In order to implement sustainable growth of the Blue Economy in the face of climate change, we need to foster a better understanding of how climate, economic, societal and political developments interact with each other and on what time scales actions and transformations need to take place.

The stakeholders involved in the study are aware of climate change and its impact on the local environment. Practitioners from the German North Sea regions Blue Economy depend on various levels on a functioning ecosystem and future changes will have both negative and positive effects on the economy. Representatives from the seafood sector, including fisheries, aquaculture and fish processing, see threats and opportunities coming with a changing climate. For local fisheries, the geographical shift of species pose a threat to the income, if fisheries management and policy will not become more flexible in order to adapt to changing abundances of valuable fish species (Gaines et al., 2018). A shift in fish species caught in the area will also affect the fish processing, since machines for processing are mostly adapted to certain species. Therefore, an increased financial effort will be necessary to adapt the processing to new species. As mentioned by the participants of WS1 the ships design needed to be adapted to future sea conditions, with higher waves and stronger storms in order to retain sea time for fishing (Cheung et al., 2012). Here the participants also saw a need for cooperation between enterprises and science to integrate predictions of climate change impacts and ship design.

All the interviewed companies in the seafood sectors ($n = 9$) have already or are in the process of implementing strategies for sustainable development and climate change mitigation and are hoping to achieve a competitive advantage compared to international competitors. Most of them do not see climate change as an urgent threat. Many participants mentioned that international competition and globalization in the Blue Economy sectors pose a greater immediate threat for a sustainable development of the seafood sector in the area. A strategy small-scale fishermen and fish processors are following, is increasing the value of the seafood products through local processing and marketing in the region. In the integrated development strategies for fisheries of coastal communities along German North Sea coast, synergies between fisheries, fish processing and tourisms are clearly mentioned as a future way to keep coastal communities culturally and economically viable (AFW and COFAD, 2007; RegionNord, 2015; FBG and COFAD, 2016).

Environmental changes related to climate change are already affecting or will affect the different surveyed sectors in the future. These changes are in a certain way predictable, the pace of change is relatively slow, and continuously, so the different sectors may adapt to these changes, with or without the help of politics. Other issues not related to climate change, such as political decisions and anthropogenic activities are affecting sustainable growth much faster and stronger. These interactions and dependencies of environmental changes and socio-economic drivers as narrated by the participants of the workshops and interviews and are visualized as a conceptual model in **Figure 1**. The conceptual

model shows in complex social-ecological systems ecological factors influence and are influenced by social, economic and political factors.

A major concern mentioned by the practitioners in WS1 and in the interviews was that political decisions and developments are less predictable, occur in shorter time scales and have a greater impact on the sectors than the slow progress of climate change. The Brexit vote and its long-lasting negotiations pose an uncertainty especially for the seafood sector since British waters are fished by different EU-countries, including Germany (Defra, 2019). Additionally, other anthropogenic activities, like dredging of rivers for shipping pose a great threat for locally produced shellfish and tourism through increased sediment load and turbidity of the waters (de Jonge, 2000). This may become one reason of declining blue mussel production in the region before increasing sea surface temperatures and ocean acidification. In the future, actions at sea would have to be coordinated differently implementing MSP (Douvere and Ehler, 2009), securing common ocean space for the users (Childs and Hicks, 2019).

CONCLUSION

Despite the observed increase in contested science findings and ongoing societal polarization, the actors in the local Blue Growth and Blue Economy sectors show a strong consensus that climate change is real, happening and affecting local communities in their daily livelihoods. Additionally, they are aware that sustainable growth derived from marine resources also make it mandatory that they are at the same time not depleted and preserved for the following generations. Most stakeholders see the ocean as natural capital and especially for the coastal communities involved in traditional sectors such as the small-scale shrimp and mussel fisheries and coastal tourisms the ocean is providing livelihoods. Fostering climate change adaptation and mitigation through further financial support from the government alongside with the development of novel strategies for the development of local sustainable livelihoods will ensure economic viability of the Blue Growth and Blue Economy sectors in the German North Sea region. However, other drivers like national and international political developments and other anthropogenic activities might interfere with the quest for long term transformative planning, since the current fast pace of observable changes in the environment may strongly differ from those in society and politics. Therefore, decision-making processes in politics and economics need to be faster, more flexible but at the same moment exhibit resilience in future proofing their planning. Fostering networks between practitioners, scientists and political decision makers will help both the Blue Economy and Blue Growth sectors to position themselves well for the future and increase adaptive capacity through increased knowledge sharing.

The study shows that the two cohorts of scientists address climate change effects differently. It is noteworthy that younger scientists place a large importance on the inter- and *trans*-disciplinarily of research approaches as well as on teaching sustainability, especially to younger generations. This observation is very much reflected in the recent "Fridays for Future" movement, where young people are increasingly calling for stronger measures from politics to stop the accelerating climate change to sustain a livable future earth. Sustainability means to meet the current generations' needs while sustaining the ability of future generations to do the same. Future generations are exactly asking for this, and we, the scientific community and citizens of the Earth need to follow this call.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This project was exempted from ethics approval in accordance with the regulations of the German Research Foundation (DFG) and the Council for Social and Economic Data (RatSWD), as all collected information was anonymous and non-sensitive and participants are not identifiable. Participants were explicitly informed about and consented to the aim of the study, the methodology and about what data will be collected, processed, stored and published. All data were collected, stored and processes in compliance with the General Data Protection Regulation (GDPR).

AUTHOR CONTRIBUTIONS

CH is lead author, conceptualized and designed the study, wrote and reviewed the manuscript, and prepared it for submission. MS and AB conceptualized and designed the study, conducted the research, provided input to introduction, methodology and results, and reviewed the manuscript. DN conducted the research, provided input to the introduction, methodology and results, and reviewed the manuscript. GK provided input to introduction, methodology and discussion, and reviewed the manuscript. BB conceptualized the study, provided input to introduction, methodology and discussion, and reviewed the manuscript.

FUNDING

The projects "Biodiversity and Climate Change: Impacts on Local Stakeholder on the North Sea Coast" (BioDiv; grant no. PAGESKP077) and "Blue Growth in a Changing Environment" (BlueChange; grant no. IP80770003) were funded under the umbrella of the "Earth System Knowledge Platform (ESKP)" Call for Tender at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research. The "Earth System Knowledge Platform (ESKP)" is the knowledge platform of the Research Field Earth and Environment of the Helmholtz Association. It centers around knowledge transfer between science and society. The first workshop (WS1) with a broad audience was endorsed by the "European Maritime Day 2016."

ACKNOWLEDGMENTS

This work is based on the knowledge of experts and representatives from different Blue Economy sectors as well as from scientists. The findings would not have been possible without the invaluable expertise of the stakeholders who participated in the workshops and interviews, which we gratefully acknowledge.

REFERENCES

AFW, and COFAD, (2007). *Strategie Für Eine Integrierte Örtliche Entwicklung des Fischwirtschaftsgebiets Niedersächsische Nordseeküste*. Cuxhaven: Agentur für Wirtschaftsförderung.

Allison, E. H., Perry, A. L., Badjeck, M. C., Adger, W. N., Brown, K., and Conway, D. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish Fish.* 10, 173–196. doi: 10.1111/j.1467-2979.2008.00310.x

Attrill, M. J., Wright, J., and Edwards, M. (2007). Climate-related increases in jellyfish frequency suggest a more gelatinous future for the North Sea. *Limnol Oceanogr.* 52, 480–485. doi: 10.4319/lo.2007.52.1.0480

Barbesgaard, M. (2018). Blue growth: savior or ocean grabbing? *J. Peasant Stud.* 45, 130–149. doi: 10.1080/03066150.2017.1377186

Baudron, A. R., and Fernandes, P. G. (2015). Adverse consequences of stock recovery: European hake, a new "choke" species under a discard ban? *Fish Fish.* 16, 563–575. doi: 10.1111/faf.12079

BMVBS, (2009). "Anlage zur verordnung über die raumordnung in der deutschen ausschließlichen wirtschaftszone in der nordsee (AWZ Nordsee-ROV)," in *Stadtentwicklung Der Bundesminister für Verkehr*, (Berlin: Bundesanzeiger).

Brander, K. (2010). Impacts of climate change on fisheries. *J. Mar. Syst.* 79, 389–402. doi: 10.1016/j.jmarsys.2008.12.015

Brander, K., Blom, G., Borges, M. F., Erzini, K., Henderson, G., and MacKenzie, B. R. (2003). Changes in the fish distribution in the eastern North Atlantic: are we seeing a coherent response to changing temperature? *ICES Mar. Sci. Symposia* 219, 261–270.

Brown, J., and Isaacs, D. (2007). *THE WORLD CAFÉ COMMUNITY. 2005. The World Café: Shaping our Futures Through Conversations that Matter*. San Francisco, CA: Bernett-Koehler.

Burge, C. A., Mark Eakin, C., Friedman, C. S., Froelich, B., Hershberger, P. K., and Hofmann, E. E. (2014). Climate change influences on marine infectious diseases: implications for management and society. *Ann. Rev. Mar. Sci.* 6, 249–277. doi: 10.1146/annurev-marine-010213-135029

Callaway, R., Shinn, A. P., Grenfell, S. E., Bron, J. E., Burnell, G., and Cook, E. J. (2012). Review of climate change impacts on marine aquaculture in the UK and Ireland. *Aquat. Conserv. -Mar. Freshw. Ecosyst.* 22, 389–421. doi: 10.1002/aqc.2247

Carstensen, D., Froese, R., Opitz, S., and Otto, T. (2014). *Ökologischer und Ökonomischer Nutzen Fischereilicher Regulierungen in Meeresschutzgebieten*. Vilm: Bundesamt für Naturschutz.

Cheung, W. W. L., Jones, M. C., Lam, V. W. Y., Miller, D. D., Ota, Y., Teh, L., et al. (2017). Transform high seas management to build climate resilience in marine seafood supply. *Fish Fish.* 18, 254–263. doi: 10.1111/faf.12177

Cheung, W. W. L., Pinnegar, J., Merino, G., Jones, M. C., and Barange, M. (2012). Review of climate change impacts on marine fisheries in the UK and Ireland. *Aquat. Conserv. Mar. Freshw. Ecosyst* 22, 368–388. doi: 10.1002/aqc.2248

Childs, J. R., and Hicks, C. C. (2019). Securing the blue: political ecologies of the blue economy in Africa. *J. f Polit. Ecol.* 26, 323–340. doi: 10.2458/v26i1.23162

de Jonge, V. N. (2000). Importance of temporal and spatial scales in applying biological and physical process knowledge in coastal management, an example for the Ems estuary. *Cont. Shelf Res.* 20, 1655–1686. doi: 10.1016/s0278-4343(00)00042-x

Defra, (2019). *Guidance - The fisheries Sector and Preparing for Brexit Edited by Food & Rural Affairs Department for Environment*. London: Defra.

Doney, S. C., Ruckelshaus, M., Duffy, J. E., Barry, J. P., Chan, F., and English, C. A. (2012). Climate change impacts on marine ecosystems. *Ann. Rev. Mar. Sci.* 4, 11–37. doi: 10.1146/annurev-marine-041911-111611

Döring, M., and Ratter, B. (2017). The regional framing of climate change: towards a place-based perspective on regional climate change perception in north Frisia. *J. Coast. Conserv.* 22, 131–143. doi: 10.1007/s11852-016-0478-0

Douvere, F., and Ehler, C. N. (2009). New perspectives on sea use management: initial findings from European experience with marine spatial planning. *J. Environ. Manage* 90, 77–88. doi: 10.1016/j.jenvman.2008.07.004

Dulvy, N. K., Rogers, S. I., Jennings, S., Stelzenmuller, V., Dye, S. R., and Skjoldal, H. R. (2008). Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas. *J. Appl. Ecol.* 45, 1029–1039. doi: 10.1111/j.1365-2664.2008.01488.x

EC. (2017). "Report on the blue growth strategy. towards more sustainable growth and jobs in the blue economy," in *Commission Staff Working Docment*, (Brussels: European Commission).

Edwards, M., and Richardson, A. J. (2004). Impact of climate change on marine pelagic phenology and trophic mismatch. *Nature* 430, 881–884. doi: 10.1038/nature02808

Eikeset, A. M., Mazzarella, A. B., Daviosdottir, B., Klinger, D. H., Levin, S. A., Rovenskaya, E., et al. (2018). What is blue growth? The semantics of "Sustainable Development" of marine environments. *Mar. Policy* 87, 177–179. doi: 10.1016/j.marpol.2017.10.019

Emeis, K.-C., van Beusekom, J., Callies, U., Ebinghaus, R., Kannen, A., and Kraus, G. (2015). The North Sea — A shelf sea in the Anthropocene. *J. Mar. Syst.* 141, 18–33. doi: 10.1016/j.jmarsys.2014.03.012

EU, (2016). "Strategic Cooperation on Blue Growth in the North Sea," in *Workshop Background Paper*, (Brussels: European Union).

FBG, and COFAD, (2016). *Strategie für Eine Integrierte Örtliche Entwicklung des Fischwirtschaftsgebiets Fischereihafen Bremerhaven*. Bremerhaven: Fischereihafen-Betriebsgesellschaft mbH.

Franke, H. D., and Gutow, L. (2004). Long-term changes in the macrozoobenthos around the rocky island of Helgoland (German Bight, North Sea). *Helgol. Mar. Res.* 58, 303–310. doi: 10.1007/s10152-004-0193-3

Gaines, S. D., Costello, C., Owashi, B., Mangin, T., Bone, J., and Molinos, J. G. (2018). Improved fisheries management could offset many negative effects of climate change. *Sci. Adv.* 4:eaao1378. doi: 10.1126/sciadv.aao1378

Harley, C. D., Randall Hughes, A., Hultgren, K. M., Miner, B. G., Sorte, C. J., and Thornber, C. S. (2006). The impacts of climate change in coastal marine systems. *Ecol. Lett.* 9, 228–241. doi: 10.1111/j.1461-0248.2005.00871.x

Hawkins, A. J. S., Pascoe, P. L., Parry, H., Brinsley, M., Black, K. D., and McGonigle, C. (2013). Shellsim: a generic model of growth and environmental effects validated across contrasting habitats in bivalve shellfish. *J. Shellfish Res.* 32, 237–253. doi: 10.2983/035.032.0201

Heath, M. R., Neat, F. C., Pinnegar, J. K., Reid, D. G., Sims, D. W., and Wright, P. J. (2012). Review of climate change impacts on marine fish and shellfish around the UK and Ireland. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 22, 337–367. doi: 10.1002/aqc.2244

Hellmann, J. J., Byers, J. E., Bierwagen, B. G., and Dukes, J. S. (2008). Five potential consequences of climate change for invasive species. *Conserv. Biol.* 22, 534–543. doi: 10.1111/j.1523-1739.2008.00951.x

Hörterer, C., Schupp, M. F., Benkens, A., and Buck, B. H. (2017). *People and the North Sea Under Changing Climate*. Bremerhaven: Alfred Wegener Institute, Helmholtz-Centre for Polar und Marine Research.

Hörterer, C., Schupp, M. F., Benkens, A., and Buck, B. H. (2018). "Climate change and biodiversity—implications for the local fisheries sector," in *Building Bridges at the Science-Stakeholder Interface: Towards Knowledge Exchange in Earth System Science*, ed. Gesche Krause, (Cham: Springer International Publishing), 31–38. doi: 10.1007/978-3-319-75919-7_5

IPCC, (2018). "Summary for Policymakers," in *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, eds V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, et al. (Geneva: IPCC).

Jones, S. J., Lima, F. P., and Wethey, D. S. (2010). Rising environmental temperatures and biogeography: poleward range contraction of the blue mussel,

Mytilus edulis L., in the western Atlantic. *J. Biogeogr.* 37, 2243–2259. doi: 10.1111/j.1365-2699.2010.02386.x

Klein, R. A. (2011). Responsible cruise tourism: issues of cruise tourism and sustainability. *J. Hosp. Tour. Manag.* 18, 107–116. doi: 10.1375/jhtm.18.1.107

Koch, M., Behnken, K., Schneider, B., Gatke, D., Thielking, K. J., and Wurthmann, H. (2015). *KLimaAnpassungsStrategie Extreme Regenereignisse (KLAS) - Schlussbericht des Projektes „ Umgang mit Starkregenereignissen in der Stadtgemeinde Bremen*. Bremen: Der Senator für Umwelt, Bau und Verkehr.

Lowe, J., Howard, T., Pardaens, A., Tinker, J., Holt, J., and Wakelin, S. (2009). *UK Climate Projections Science Report: Marine and Coastal Projections*. Exeter: Met Office Hadley Centre.

Metcalf, S. J., van Putten, E. I., Frusher, S., Marshall, N. A., Tull, M., and Caputi, N. (2015). Measuring the vulnerability of marine social-ecological systems: a prerequisite for the identification of climate change adaptations. *Ecol. Soc.* 20:35. doi: 10.5751/Es-07509-200235

Mortensen, L. O., Ulrich, C., Hansen, J., and Hald, R. (2018). Identifying choke species challenges for an individual demersal trawler in the North Sea, lessons from conversations and data analysis. *Mar. Policy* 87, 1–11. doi: 10.1016/j.marpol.2017.09.031

nordwest2050, (2014). *Integrierte Roadmap of Change - Fahrplan für Klimaanpassung und Resilienz in der Metropolregion Bremen-Oldenburg im Nordwesten*. Bremen: nordwest2050.

Occhipinti-Ambrogi, A. (2007). Global change and marine communities: alien species and climate change. *Ma.r Pollut. Bull.* 55, 342–352. doi: 10.1016/j.marpolbul.2006.11.014

Peperzak, L. (2003). Climate change and harmful algal blooms in the North Sea. *Acta Oecol. -Int. J. Ecol.* 24, S139–S144. doi: 10.1016/S1146-609x(03)00009-2

Perry, A. L., Low, P. J., Ellis, J. R., and Reynolds, J. D. (2005). Climate change and distribution shifts in marine fishes. *Science* 308, 1912–1915. doi: 10.1126/science.1111322

RegionNord, (2015). *Integrierte Entwicklungsstrategie Fischwirtschaftsgebiet der LAG AktivRegion Dithmarschen e.V.*. Dithmarschen: RegionNord.

Reise, K. (2005). Coast of change: habitat loss and transformations in the Wadden Sea. *Helgol. Mar. Res.* 59, 9–21. doi: 10.1007/s10152-004-0202-6

Rijnsdorp, A. D., Peck, M. A., Engelhard, G. H., Mollmann, C., and Pinnegar, J. K. (2009). Resolving the effect of climate change on fish populations. *Ices J. Mar. Sci.* 66, 1570–1583. doi: 10.1093/icesjms/fsp056

Schuchardt, B., and Wittig, S. (2012). *Vulnerabilität der Metropolregion Bremen-Oldenburg gegenüber dem Klimawandel (Synthesebericht). nordwest2050-Berichte Heft 2*. Bremen: Projektkonsortium.

Schupp, M. F., Bocci, M., Depellegrin, D., Kafas, A., Kyriazi, Z., and Lukic, I. (2019). Toward a common understanding of ocean multi-use. *Front. Mar. Sci.* 6:165. doi: 10.3389/fmars.2019.00165

Seitz, R. D., Wennhage, H., Bergstr öm, U., Lipcius, R. N., and Ysebaert, T. (2013). Ecological value of coastal habitats for commercially and ecologically important species. *ICES J. Mar. Sci.* 71, 648–665. doi: 10.1093/icesjms/fst152

Silver, J. J., Gray, N. J., Campbell, L. M., Fairbanks, L. W., and Gruby, R. L. (2015). Blue economy and competing discourses in international oceans governance. *J. Environ. Dev.* 24, 135–160. doi: 10.1177/1070496515580797

Sims, R. (2009). Food, place and authenticity: local food and the sustainable tourism experience. *J. Sustain. Tour.* 17, 321–336. doi: 10.1080/09669580802359293

Sorte, C. J. B., Williams, S. L., and Carlton, J. T. (2010). "Marine range shifts and species introductions: comparative spread rates and community impacts. *Global Ecol. Biogeogr.* 19, 303–316. doi: 10.1111/j.1466-8238.2009.00519.x

Stoll, J. S., Dubik, B. A., and Campbell, L. M. (2015). Local seafood: rethinking the direct marketing paradigm. *Ecol. Soc.* 20:40. doi: 10.5751/ES-07686-200240

Tiller, R., De Kok, J. L., Vermeiren, K., Richards, R., Van Ardelan, M., and Bailey, J. (2016). Stakeholder perceptions of links between environmental changes to their socio-ecological system and their adaptive capacity in the region of troms, Norway. *Front. Mar. Sci.* 3:267. doi: 10.3389/fmars.2016.00267

UN, (2014). *Blue Economy Concept Paper*. New York, NY: United Nations.

UN, (2017). "Factsheet: People and Oceans," in *The Ocean Conference*, (New York, NY: United Nations).

Vensim, (2015). *Software 7.3*. Harvard, MA: Ventana Systems, Inc.

Voyer, M., Quirk, G., McIlgorm, A., and Azmi, K. (2018). Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance? *J. Environ. Policy Plann.* 20, 595–616. doi: 10.1080/1523908x.2018.1473153

Voyer, M., and van Leeuwen, J. (2019). 'Social license to operate' in the Blue Economy. *Resour. Policy* 62, 102–113. doi: 10.1016/j.resourpol.2019.02.020

Westerbom, M., Mustonen, O., Jaatinen, K., Kilpi, M., and Norkko, A. (2019). Population dynamics at the range margin: implications of climate change on sublittoral blue mussels (Mytilus trossulus). *Front. Mar. Sci.* 6:292. doi: 10.3389/fmars.2019.00292

Westlund, L., Poulain, F., Bage, H., and van Anrooy, R. (2007). *Disaster response and Risk Management in the Fisheries Sector., FAO Fisheries Technical Paper*. Rome: FAO.

Wiltshire, K. H., Kraberg, A., Bartsch, I., Boersma, M., Franke, H.-D., and Freund, J. (2009). Helgoland Roads, North Sea: 45 Years of Change. *Estuaries Coasts* 33, 295–310. doi: 10.1007/s12237-009-9228-y

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.